IRON STATUS OF HIGH SCHOOL HOME ECONOMICS STUDENTS

By

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CHAPTER I

INTRODUCTION

Iron deficiency is a world wide problem. It is probably the most common dietary factor leading to anemia in the world. "Iron deficiency and its attending anemia are not often the immediate, direct cause of death, but they contribute most importantly to the weakness, ill health and substandard performance of many millions of people," according to Moore (1). A conservative estimate places the incidence of iron deficiency in the United States at 18,000,000 persons (2). Mauer (3) calls it the most common of the deficiency disease syndromes seen in children of this country. Studies performed in the United States indicate that 10 to 20 per cent of apparently healthy young women and nearly 100 per cent of pregnant women have incidence of iron deficiency (2, 4). The incidence of iron deficiency among adolescent girls is especially important because they are in a vulnerable position due to increased needs for growth and menstruation.

Iron deficiency occurs when the body's need for iron exceeds the supply due to a less than adequate dietary intake. It is the end result of an imbalance between iron assimilation and iron loss. For example, a menstruating woman with a poor diet could be taking in less iron than she is losing. Severe iron deficiency can lead to anemia which is a condition in which there is a reduction in the hemoglobin concentration of the circulating blood (5). This usually happens when the body's

needs for iron are high and the diet does not supply enough. It is common during periods of stress such as growth, menstruation, pregnancy or excessive blood loss.

Because iron deficiency is such an important nutritional problem, this study was designed to determine its incidence in a group of adolescent girls in a small Oklahoma town. High school home economics students who volunteered were the subjects for this study because it was felt that these students would have been exposed to aspects of good nutrition. The study was designed to collect data on dietary intakes which was to be analyzed for protein, calorie, and iron intakes and compared to the Recommended Dietary Allowances for each nutrient for teen-age girls. Further, the diets were to be compared to the Daily Food Guide (Basic Four) to determine eating patterns and to see if the diets were well balanced. Blood samples were analyzed for hemoglobin, hematocrit, and red cell indices, measures of the iron content of the blood, which give an indication of the incidence of iron deficiency in this age group. A dietary history was to be completed to indicate the food habits of each girl. A nutrition quiz was to be taken to indicate each girl's knowledge of nutrition. This was done to help determine if the girls had the knowledge of how to choose a well-balanced diet.

Objectives of the study were:

(a) To determine whether girls who take home economics in grades 9 to 12 choose a well-balanced diet.

(b) To determine if iron deficiency occurs in a group of teen-age girls.

(c) To determine how nutrient intake of the girl compares to national studies.

(d) To determine whether nutrient intakes of iron, protein, and calories were adequate according to Recommended Dietary Allowances.

(e) To determine whether such factors as age, nutrition knowledge, food habits and education of parents influenced iron status of these girls.

Hypotheses for the study were the following:

(a) Even though they have the knowledge of what makes a well-balanced diet, the majority of teen-age girls do not eat a balanced diet when compared to the Daily Food Guide.

(b) The majority of these girls will have diets which are below the Recommended Dietary Allowances for protein and iron.

(c) The hemoglobin and hematocrit levels of these girls will be low or below normal.

CHAPTER II

REVIEW OF LITERATURE

History of Iron

Iron is a metallic element widely distributed in nature. It is vital for biological processes. Every tissue in the body contains some iron. Iron was probably used therapeutically as early as 1500 B.C. (2). It was called the "metal of Heaven" by ancient civilizations and used therapeutically both in Egypt and Mesopotamia. Ancient physicians correctly guessed that iron is the source of the color of blood. Pliny the Elder cited the biological role of iron in the first century A.D. (2).

In the tenth century, ibn-Sina in his Canon of Medicine advocated iron rust in wine for all sorts of disorders.

> Iron has a styptic property by which the flow of women can be made to subside. Wine, in which iron has been quenched, restrains chronic abdominal discharges; is good for loose stools; it improves incontinence of urine; it restrains menstrual flow; it restores sexual potency and strength to men (2).

In the seventeenth century iron began to be used as specific therapy for a single disease, chlorosis, which affected young women. The name derived from the fact that when women developed chlorosis they became so pale their skin seemed to take on a yellow-green tint. The term was first used by Jean Varandol (6). In 1640 Lazarus Riverius enumerated ten major manifestations of chlorosis: pallor, edema, heaviness of body limbs, dypsnea, palpitation, headache, rapid pulse,

unusually sound and prolonged sleep, and cessation of the menses (2). Shakespeare also referred to chlorosis in several of his works. Sydenham is credited with identifying iron as a specific remedy for chlorosis in 1681 and treated it with iron filings steeped in Rhine wine (6).

In 1713 two chemists, Lemery and Geoffry, showed that the ash of blood contained iron (2). In 1747 Menghini demonstrated that iron content of the blood could be increased in experimental animals by placing them on iron-rich diets (6).

Pierre Blaud, a French physician, started treating chlorosis with iron in 1831. He prescribed tablets containing ferrous sulfate and potassium carbonate in massive doses to "restore the coloring substance to the blood." He seems to have been the first to use a ferrous salt. His pills became widely known throughout the world as "the veritable pills of Dr. Blaud" because they produced such outstanding results (2). His theories on treating chlorosis fell out of favor in the last half of the 19th century. It was not until 1932 when Heath, Strauss, and Castle demonstrated that inorganic iron is incorporated quantitatively into hemoglobin that Dr. Blaud's theories were conclusively proven true.

Function and Distribution of Iron in the Body

Iron is bound to a variety of protein molecules. It is a component of hemoglobin, myoglobin, cytochrome, and the enzymes catalase and peroxidase (7, 8). The iron is a component of a porphyrin in all of these compounds. The remainder of the iron, which is almost entirely

protein bound, includes storage (ferritin) and transport (transferrin) forms of iron (9, 10, 11).

The function of hemoglobin is to shuttle oxygen from lung to tissue and carbon dioxide from tissue to lung. Iron in the body is almost exclusively confined to the processes of cellular respiration (11, 12). Hemoglobin, which is the principal component of the red blood cells, accounts for 65 to 70 per cent of the iron in a person's body. Myoglobin is a respiratory pigment found in the muscles which serves as an oxygen carrier. Three to five per cent of the iron in the body is in the form of myoglobin. The cytochromes, which are involved in the electron transport in tissue respiration and the formation of high energy ATP bonds, contain 0.1 per cent of the body's iron. Catalase and transferrin each account for 0.1 per cent of the body's iron. Ferritin accounts for 25 to 30 per cent of the body's iron. Normal man has 35 to 50 milligrams of iron per kilogram of body weight for a total of three to four grams of body iron (13, 14, 15). See Table I.

Iron Requirements

The need for iron by a person varies greatly according to age and circumstances. Dietary iron is required to: (a) replace daily losses; (b) replace menstrual losses; (c) supplement the body's greater need for iron during growth, pregnancy, and lactation; and (d) form an iron reserve which is available in case of blood loss (8, 11).

Daily losses of iron range from 0.5 to 1.0 milligrams (mg) per day. These losses occur primarily in the gastrointestinal tract from exfoliation of the cells, some bleeding, and excretion of bile. This accounts for three-fourths of the daily iron loss. One-fourth of the body iron

is lost through normal exfoliation of the skin and some losses probably due to sweat (13).

TABLE I

DISTRIBUTION OF BODY IRON (15)

Iron-Containing Compound in Body	Amount (gm)	Per Cent
Hemoglobin	2.1 - 2.5	65 - 70
Myoglobin	.13	3 - 5
Cytochromes	.004	0.1
Catalase	.004	0.1
Transferrin	.004	0.1
Ferritin	0.8 - 1.5	25 - 30
Total Body Iron	3 - 4 gm	100 %

In menstruating woman, the major, and most variable, component of iron loss is the menstrual flow (16, 17). Average loss of blood during a menstrual period is 35 to 70 milliliters (ml), which represents a loss of 16 to 32 mg of iron. Upper normal limits of blood loss are 60 to 80 ml. Losses above 80 ml per period (menorrhagia) involve a great risk of developing negative iron balance (18, 19, 20). Moore (1) states that the average monthly loss of menstrual iron is 20 mg, or 0.7 mg per day, but reports losses ranging from 2.3 to 79 mg. Mayer (21) reports the average daily iron loss to be 0.6 mg per day. However, losses have also been reported of 1.1 to 2.0 mg per day. Beaton et al. (16) have reported daily menstrual iron losses of 0.44 mg per day.

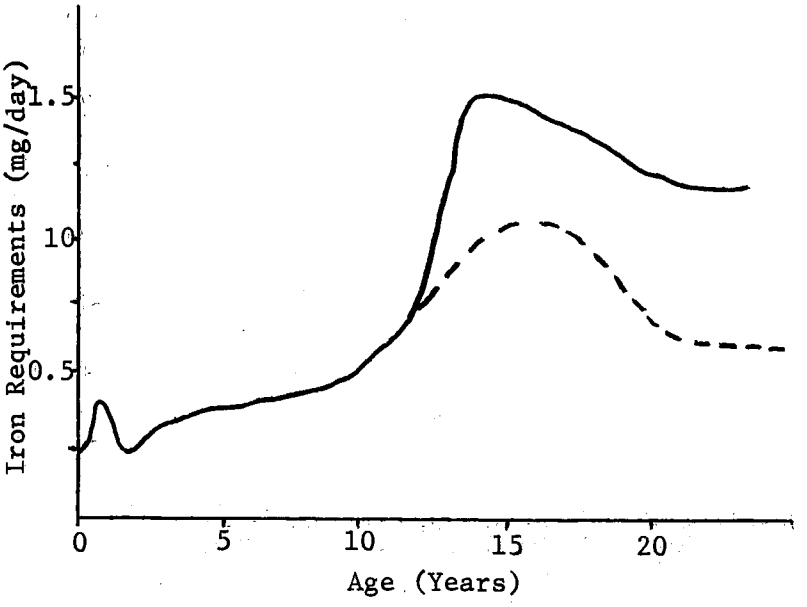
Periods of rapid growth increase iron requirements because of expanding blood volume. This occurs in young children and adolescents and increases iron requirements by 0.6 mg per day (1). Iron depletion is common in adolescent girls because more iron is required for the growth spurt and for replacement of menstrual losses (3). Another period of rapid growth occurs during pregnancy when increased blood volume, fetal requirements, and blood loss during delivery increase iron requirements greatly. Finch (13) states that the fetus gains 270 mg of iron, 240 mg is lost at delivery, other losses require 170 mg for a total iron requirement during pregnancy of 680 mg.

In summary, iron requirements for optimal body function are: adult males and post-menopausal females, 0.5 to 1.0 mg per day; menstruating females, 1 to 2 mg per day; children, 0.5 to 1.5 mg per day; girls from 12 to 15 years of age, 1 to 2.5 mg per day (8). See Figure 1.

Recommended Dietary Allowances for Iron

In 1943 the Recommended Dietary Allowances (RDA) were developed by the Food and Nutrition Board of the National Academy of Sciences - National Research Council (22) as a guideline for desirable nutrition. The Recommended Dietary Allowance for iron is that amount over the minimum requirement with a safety margin added which will meet the needs of practically all healthy persons in the United States.

These allowances are revised periodically as scientific knowledge increases. The allowances are intended to be used as guidelines for interpreting food consumption of individuals. It should not be assumed that malnutrition will occur when the recommendations are not met however.



The daily iron requirement through life is indicated. For those over the age of 12 the line divides into the requirements of the female and the male (dotted line). (15)

Figure 1. Iron Requirements in Man

The iron allowance for certain age groups was increased in 1963 and again in 1968. In 1963 the allowance for children was increased from 12 to 15 mg daily (23). In 1968 the allowance for females from age ten through child-bearing years was increased to 18 mg per day. This allowance was increased because of the widespread occurrence of iron deficiency (24). If met, this new allowance should permit sufficient accumulation of iron stores to avoid the need for iron therapy during pregnancy.

The 1968 Recommended Dietary Allowances for iron are: men and nonmenstruating women, 10 mg per day; menstruating and pregnant women, 18 mg per day; children, 10 to 15 mg per day; and infants, 6 to 15 mg per day (8). These allowances are set at this level because absorption

from food is estimated to be 10 per cent (22). If these allowances are not met and 10 per cent is absorbed, body iron requirements should be met.

The iron content of most adequate diets is estimated to be 6 mg of iron per 1000 kilocalories (13, 22). Men and nonmenstruating women can usually meet their allowances with diet alone, but menstruating women, adolescents, and some children may require iron supplementation to meet their allowances.

Iron Absorption

Absorption of iron occurs mainly in the duodenal epithelium (25). Under normal conditions very little iron is excreted and very little is absorbed. The iron in a person's body is reused several times. The amount of iron that will be absorbed depends on the body's need for iron, conditions existing within the intestine, and the food mixture that is fed. There are limited ways for the body to excrete excess iron, so its absorption must be controlled carefully (26, 27).

When a person's body needs more iron such as in growth, pregnancy, and anemia, erythropoiesis increases, transferrin saturation is lowered, and iron absorption is increased. In a healthy person about 10 per cent of the iron ingested is absorbed. When a person's need for iron increases, absorption may be increased 2 to 10 times the normal rate (28).

Dietary iron, which is usually in the ferric state is reduced to ferrous iron in the acid medium of the stomach. In the ferrous state iron is more soluble and therefore more absorbable. Achlorhydria reduces the absorption of iron because less is reduced to ferrous iron.

Gastrectomies reduce absorption of iron because the iron is in the stomach a shorter time and less is reduced to ferrous iron. Malabsorption syndromes also reduce absorption because of increased intestinal motility (29).

Not all of the iron in foods is available for absorption. Absorption of iron is greater from animal foods (10 to 30 per cent) than vegetables (2 to 10 per cent) (13). It has been recommended that vegetable sources of iron be eaten with animal foods to enhance iron absorption from vegetables (30, 31). The presence of ascorbic acid increases iron absorption (32). Certain sugars (fructose as compared to glucose) and certain amino acids also increase iron absorption (5). Phosphates, phytates and oxalates decrease iron absorption (10). Adequate amounts of calcium in the diet help bind phosphates and phytates and so help facilitate iron absorption (10). There is also a decrease in the rate of iron absorption on a low protein diet (2).

The upper duodenum is the major site of iron absorption because pH and redox potential are optimal. After iron has been reduced to the ferrous state it must traverse the intestinal epithelium to the mucosa to enter the bloodstream. Iron is transported across the epithelial cell as part of an active metabolic process (15). Probably iron is bound to a low molecular weight non-protein substance and carried through the epithelium to the mucosal cells (33). This iron complex diffuses directly to the vascular border and is transferred across the cell membrane into the plasma. The transfer of iron is mediated by the mucosal cell. It does not appear to require oxidative energy. Iron that is not rapidly transported to the plasma probably accumulates in the mucosal cell and combines with a protein apoferritin to form

ferritin. This ferritin complex probably keeps the iron it contains from being absorbed (10).

Iron Transport and Storage

Iron enters the plasma from the intestine, from breakdown of hemoglobin, from tissue stores, and from tissue enzymes. This iron which enters the plasma is converted to the ferric state. Iron is carried to its storage areas by a specific protein, transferrin (or siderophilin) (7). Transferrin is formed in the liver and is normally present in the plasma in a concentration sufficient to bind 280 to 400 micrograms of iron per 100 ml of plasma.

The normal content of iron in the plasma ranges from 60 to 200 micrograms (mcg). Plasma iron is decreased in iron deficiency and total iron binding capacity (T.I.B.C.) increases. Each molecule of transferrin is capable of binding two molecules of iron. Transferrin functions as a transport protein. It shuttles iron atoms between tissues without itself being assimilated. Approximately 27 mg of iron enter and leave the blood plasma each day in a normal adult (7).

The transferrin transports the iron to selective receptor tissues throughout the body. The main storage organs are the liver, spleen, and bone marrow which participate in producing red blood cells. About one gram of the iron is present in the energy producing enzyme system.

Under conditions of normal erythropoietic activity up to 90 per cent of the iron absorbed and passing through the plasma compartment will enter the bone marrow and some 70 per cent of it will be incorporated into the hemoglobin of circulating erythrocytes within 7 to 10 days (33). Iron is stored as ferritin and as hemosiderin which is a

secondary, less soluble compound. From these storage areas iron is mobilized for hemoglobin synthesis as needed. From 20 to 25 mg of iron is involved daily in hemoglobin synthesis but 90 per cent of this is iron that has been used before.

Hemoglobin

Hemoglobin is a conjugated protein with a molecular weight of 64,458. It is a globular molecule made up of four subunits. Each subunit contains a heme moiety conjugated to a polypeptide. Heme contains iron in the center of a porphyrin structure (protoporphyrin - 9) and constitutes about 4 per cent of the weight of hemoglobin (34). The hemes give hemoglobin its red color. The iron content of hemoglobin is 0.3566 per cent. One gram of hemoglobin contains 3.4 mg of iron (25). The polypeptides are referred to as the globin portion of the hemoglobin molecule (35). There are two pairs of polypeptides in each hemoglobin molecule, two of the subunits containing one type of polypeptide (alpha chains) and two containing another (beta chains) (36). Heme is also part of the structure of myoglobin, the oxygen-binding pigment found in muscles, and of the respiratory enzyme, cytochrome (37).

The synthesis of hemoglobin takes place in vivo in nucleated red cells primarily in the bone marrow. This process takes about seven and one-half days. The red blood cells or erythrocytes carry hemoglobin in the circulation. The life span of the erythrocyte in man is 120 days. When the red cell disintegrates, the hemoglobin molecule is split into its components. The globin is converted to amino acids and reutilized. The iron is stored in the liver and spleen and reutilized (38). The

non-iron containing portion is converted to bilirubin and excreted as one of the bile pigments. The amount of hemoglobin in the blood averages 12 to 16 g per 100 cc (7).

Hemoglobin combines with oxygen in the lungs to form oxyhemoglobin. This is carried to the tissues where oxygen is released. Carbon dioxide is carried back to the lungs by the same hemoglobin. Carbon dioxide is released in the lungs and the process starts over.

Iron Deficiency and Anemia

Iron deficiency arises when the body's need for iron exceeds the supply. The principal causes are rapid growth of children; menstruation, pregnancy and lactation in women; and blood loss (39, 40, 41, 42, 43). The occurrence of iron deficiency is favored by a diet which contains insufficient iron (43). There are several stages of iron deficiency. The first stage is referred to as iron depletion. The second stage is referred to as iron deficiency without anemia. In both of these stages, the red blood cells are both normochromic (normal color) and normocytic (normal size) (43). The third stage of iron deficiency is called iron deficiency anemia and is characterized by red blood cells that are hypochromic and microcytic (small and pale) (40).

Anemia is defined as a deficiency of red blood corpuscles, hemoglobin, or both. Iron deficiency anemia is any anemia in which the rate of erythropoiesis is limited by the supply of available iron. The quantity of hemoglobin formed may be decreased greatly, but the iron content of the hemoglobin is constant (2).

The sequence of iron depletion leading to anemia has been defined by several investigators (15, 39, 40, 41, 42, 43, 44). The first stage

in which body iron stores are reduced is sometimes referred to as sideropenia. Plasma iron and transferrin levels remain normal. The second stage, iron deficiency without anemia or latent iron deficiency, occurs when storage iron is depleted. Serum iron concentration is less than 50 mcg per 100 ml. Transferrin saturation is less than 15 per cent. Hemoglobin synthesis is reduced and some red blood cells are produced with a decreased hemoglobin content. At this time iron absorption from food is increased. The third stage, iron deficiency anemia, occurs when normal hemoglobin content of the blood cannot be maintained despite maximum iron absorption from food. The red blood cells are hemochromic and microcytic. See Figure 2. Iron deficiency anemia has therefore been termed hypochromic microcytic anemia.

Fairbanks et al. (2), state that the term "hypochromic microcytic anemia" is used incorrectly as a synonym for iron deficiency anemia. This is because iron deficiency anemia is only one of the many disorders which result in a hypochromic, microcytic anemia. Some other causes of hypochromic microcytic anemia are chronic inflammatory disease, chronic malignant disease, and thalassemia (43, 45).

Symptoms of Iron Deficiency

Iron deficiency can affect all the systems of a body. When a person is iron deficient there will be an increased number of erythroblast precursors in the bone marrow, a diminished volume of red blood cells, and a reduction of hemoglobin breakdown products (44). Symptoms of iron deficiency and iron deficiency anemia of the integumentary system are pallor of skin, mucous membranes, conjuctivae, lips, lobes of

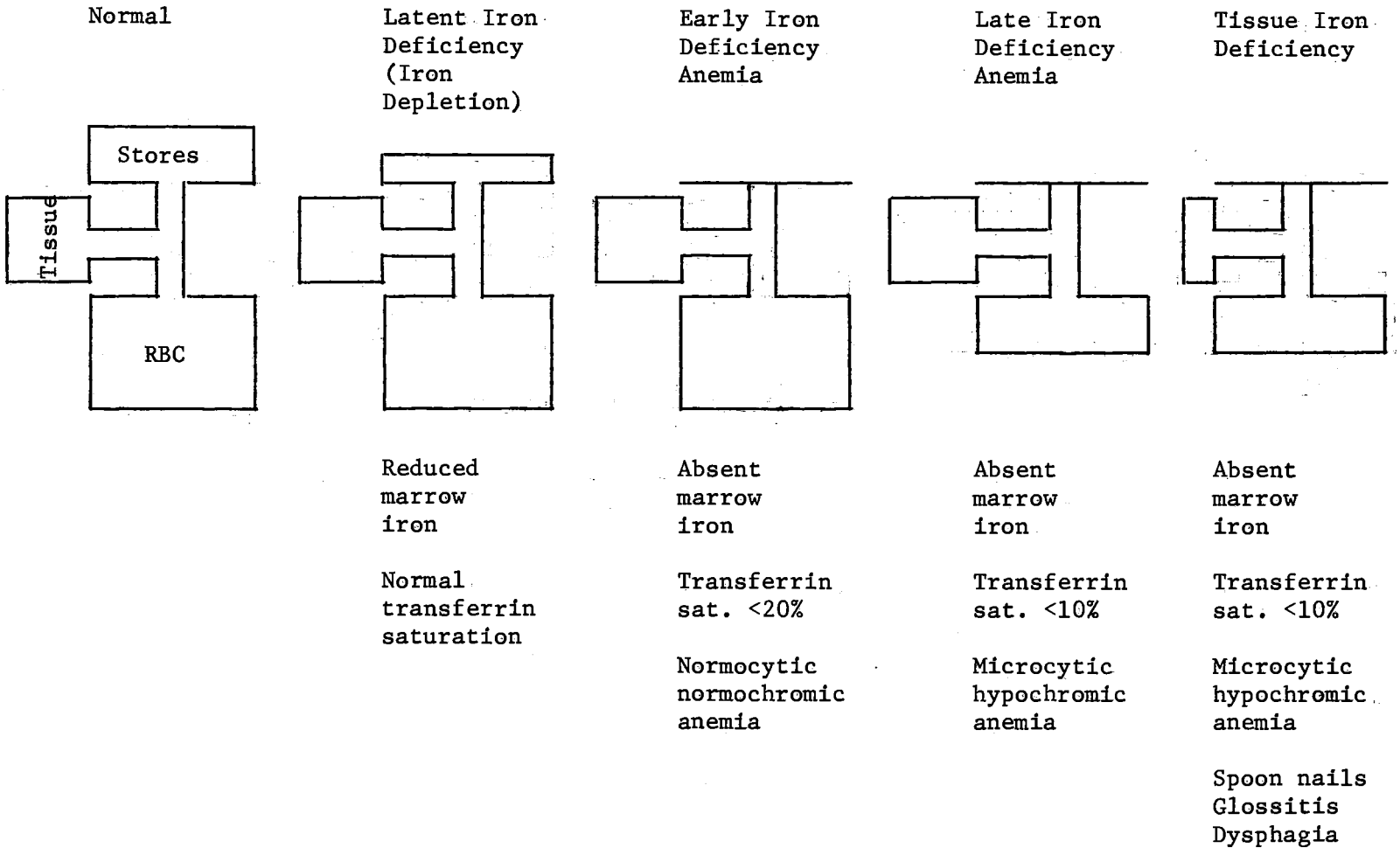


Figure 2. Sequence of Iron Depletion in Man (15)

ears, palms of hands, and nailbeds, and loss of skin elasticity (44). Nails become brittle, break easily, and may become concave instead of convex (koilonychia). Hair growth is poor and hair may have a dry dead feeling (7). Rhagades may appear at the angles of the mouth (44). The respiratory and circulatory systems are also affected. There may be dyspnea, shallow breathing, and shortness of breath. Tachycardia and even heart murmurs may occur.

Symptoms of the neuromuscular system are headache, vertigo, faintness, increased sensitivity to cold, black spots before the eyes, irritability, drowsiness, and lack of power of concentration (7, 46). Muscular weakness may occur (44). Alimentary system symptoms are anorexia, nausea, and flatulence. Amenorrhea may be a symptom displayed in the genitourinary system. In severe anemia there may be an increased basal metabolic rate. Enlargement of the liver and spleen can also occur.

In iron deficiency anemia there may sometimes be cravings for unusual or disgusting articles. This is called pica. Ice, dirt, chalk, starch, clay, and paint are some of the substances consumed in large amounts by iron deficient persons.

Diagnosing Iron Deficiency and Iron Deficiency Anemia

There are several methods of diagnosing iron deficiency and anemia. Hypochromia and microcytosis of the red blood cells has generally been considered essential for diagnosis of iron deficiency anemia (45). However an adequate iron supply may retard erythropoiesis for several weeks before these characteristics are recognizable. Methods of determination

of iron status before a hypochromic microcytic anemia is present include determination of serum iron, serum iron-binding capacity, transferrin saturation, and amount of hemosiderin in the reticuloendothelial cells (47, 48). Hemoglobin and hematocrit determinations are good indices of iron status when iron stores have been depleted enough to cause an anemia (2, 7, 15, 47, 48).

Determination of serum iron concentration gives some indication of the earlier stages of iron depletion. There are several methods of determining serum iron (43, 49). Normal serum iron concentration in males is 75 to 175 mcg per 100 ml and for women 65 to 165 mcg per 100 ml. When iron stores are depleted, serum iron falls below 65 mcg per 100 ml.

Serum iron-binding capacity is another measure of iron depletion (43, 47, 48, 50). Normal values are: males - 150 to 285 mcg per 100 ml serum; females - 144 to 322 mcg per 100 ml serum. In iron deficiency this value is increased, unless protein synthesis is depressed, because of increased absorption of iron from dietary sources (48).

Transferrin, which carries iron in the plasma, is normally 25 to 50 per cent saturated with iron (43). In iron deficiency anemia transferrin saturation is decreased to below 20 per cent. See Figure 2.

Hemosiderin present in the reticuloendothelial cells of the bone marrow is a good measure of iron stores, but it is impractical for large groups (49). Iron deficient subjects do not have stainable iron in the bone marrow (45, 51, 52).

Hemoglobin determination is one of the quickest methods of determining iron status, especially for large numbers of people (2). Normal hemoglobin levels are 14 to 16 g per 100 ml for men and 12 to 14 g per 100 ml for women (7, 43). There are several methods of hemoglobin

determination but the one most frequently used is the cyanmethemoglobin method (43). In this method a reagent is added to blood causing the iron in hemoglobin to change from ferrous to ferric. The reagent then causes a color reaction which is measured on a spectrophotometer (43). However Fairbanks (43) points out that in 1965 a new standard for optical density of cyanmethemoglobin was adopted thereby making the lower limits of normal 12.2 g per 100 ml for women and 14.3 g per 100 ml for men. Verloop (42) states that a woman is anemic when her hemoglobin level falls below 12 g per ml. In another article, it was stated that the lower limits of hemoglobin for a woman should be 12.5 g per 100 ml (53).

Hematocrit determination is usually assessed along with hemoglobin levels (50). Hematocrit is a means of determining size of red blood corpuscles (7). Hematocrit determination is done by centrifuging whole blood to separate red blood cells from white blood cells and plasma. Normal hematocrit levels are 37 to 47 for women and 42 to 52 for men (7). It has been stated that the lower limits of normal for hematocrit should be 36 for women and 40 for men (53). When a person has iron deficiency anemia his hematocrit will be low indicating red blood cells that are microcytic. There is still controversy over "normal levels" for hemoglobin and hematocrit and what levels indicate the presence of anemia.

Red cell indices, which are calculated from hemoglobin, hematocrit, and red cell count, have been used to help determine iron deficiency (7, 43). The red cell indices are mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC). These terms were first used in 1929 by Wintrobe (7). When

the MCV is below 82 it indicates a microcytic cell. MCH measures the weight of hemoglobin in an average red cell. MCH is decreased in iron deficiency. MCHC indicates the concentration of hemoglobin in an average red cell. When it is below 32 it indicates iron deficiency. However Fairbanks (43) does not feel that using red cell indices is a reliable method of determining iron deficiency because the normal ranges are not defined clearly enough.

Methodology of Nutrition Surveys

Nutrition surveys have been conducted for years to assess the nutritional status of varied groups of people (8, 54, 55, 56). Data collected in a nutritional survey includes dietary intake, clinical measures, and physical data. The first step in doing a nutrition survey is to define the population about which information is desired (57). The sample chosen should be statistically valid (47). Too small a sample is inadequate, but too large a sample is wasteful of time and money.

The next step in conducting a nutrition survey is to determine what types of survey methods will be needed. Methods used for groups are not the same as those used for individuals (58). Factors to consider in choosing the method of surveying include: how data will be collected; how amounts will be reported; how information will be expressed; the time span the survey will cover; and how the data will be used.

The methods of collecting data on food intakes, which may be written or given to a nutritionist during an interview include dietary history and food intake records. The dietary history tries to disclose

usual food patterns over a relatively long period. This would reveal deviations from usual food habits (59). The dietary history would include an account of the foods usually eaten during the course of a day recorded in meal patterns and between meal feedings. Supplementary information such as occupation, place where meals are eaten, facilities for food preparation, expenditures for food, and food preferences can also be included in the dietary history (59).

The food intake record is a report of the food eaten for one or more days (60). These reports are recorded on a specifically prepared form such as the one used in the Framingham study (61). Recipe methods and food composition analysis are two of the methods of collecting data (60). The nutritive value of the diet can be calculated from tables of food composition or samples of the diet can be analyzed for actual nutrient content (63). The nutritive value of the diet can then be evaluated by certain guidelines. In this country, the most common guideline used is the Recommended Dietary Allowances of the Food and Nutrition Board of the National Academy of Sciences - National Research Council (22, 49).

Amounts of food can be reported either as actual weights of food eaten or as measurements of food eaten (63). The quantity of food may also be estimated (59). Other relevant information, such as method of preparation, can also be reported.

When deciding on the time span the survey will cover, time and money available to conduct the survey should be considered. Time spans in various surveys have varied from one to seven days. Twenty-four hour recall methods are used frequently (64). Three day records have also been used (59, 65, 66). There is at present no agreement among

investigators as to the number of days which can give a representative picture of typical food intake under all survey conditions (59).

If a survey of factual knowledge of nutrition is desired, methods of collecting this information can be a questionnaire or a quiz (59). True - false, multiple choice, or completion questions may be used. This information can be obtained from the dietary history if desired.

Once the nutritional survey methods are determined, types of clinical evaluation should be decided upon if these are a part of the study. The actual knowledge of a person's nutrient intake is not synonymous with his nutritional evaluation. Surveys of dietary habits and calculation of nutrient intake should not be a substitute for direct evaluation of nutritional status (67).

One of the most widely used methods of evaluating nutritional status is to determine hemoglobin levels in the blood (12, 62, 68, 69). Hemoglobin levels are considered a good indices of general health of the population. The anemia of iron deficiency can be differentiated from anemia of other causes by also determining hematocrit and red cell indices. The determination of the concentration of hemoglobin in the blood is a valuable procedure in appraising nutritional status if the limitations are sufficiently appreciated and if findings are interpreted with full realization of the variability consistent with normal health (59).

Complete correlation between dietary intake over a short period and clinical or laboratory findings for an individual should not be expected because: (a) the state of a person's health reflects the cumulative effect of food consumption over a long period of time; (b) errors may be introduced by applying tables of average food values to an individual's

diet; (c) it is difficult to assess adequacy of a diet without detailed knowledge of how nutrients are absorbed by the individual; and (d) there are wide individual differences in dietary requirements and these may vary from time to time (59, 69, 70).

Iron Status in Nutrition Surveys

Only a few large scale nutrition surveys have been conducted to determine the nutritional status of large groups of people. One of these surveys was the National Nutrition Survey which because of limits of time and money was conducted in 10 states and surveyed primarily people in low income levels. In the preliminary report of the National Nutrition Survey in 1969, it was indicated that 15 per cent of the population surveyed had inadequate hemoglobin levels (71).

The final report of the Ten-State Survey was published in 1972 (72). Again the population surveyed in each state was not representative of the entire population of that state. The primary interest in each state was malnutrition among the poor. Over 86,000 persons were surveyed in the 10 states. The results of the survey indicated that a significant proportion of the population surveyed was malnourished (72). There was a high prevalence of low hemoglobin and hematocrit values throughout all segments of the population surveyed. Low hemoglobin levels were associated with low levels of serum iron and serum transferrin saturation. There was a tendency of lower hemoglobin levels to be associated with lower dietary iron intakes. These surveyors concluded that iron deficiency anemia was a widespread problem within the population surveyed and this appeared to be largely due to nutritional iron deficiency. This nutritional iron deficiency was less a reflection of poor choice of

foods than of the generally low level of iron in the American diet. School-lunch programs contributed significantly to the nutrient intake of many school children. Twenty to 35 per cent of the child's daily iron intake was provided by the school lunch.

The United States Department of Agriculture regularly conducts food consumption surveys to determine what types of foods and nutrients are being consumed (56). The Household Food Consumption Survey of 1965 was conducted on a representative sample of 14,500 men, women, and children in the United States. It was found that girls age 9 to 19 were more than 30 per cent below recommended allowances for their age group for iron. Their diets contained less than 6 mg of iron per 1000 calories. Average daily iron intake was about 11.0 mg.

In a review of the vitamin and mineral studies done in the United States from 1950 to 1968 Davis et al. (68) determined that 60 per cent of the persons studied had intakes below recommended allowances for iron at the time the studies were conducted. Of girls age 15 to 21, 38 per cent were 2/3 RDA for iron, and 10 per cent were below 1/2 RDA for iron. Through dietary intake records and biochemical data, it was suggested that diets consumed by females following puberty were poorer for most of the nutrients except ascorbic acid. Twenty-five per cent of the persons studied had below acceptable hemoglobin and hematocrit levels.

In a 1962 report on the Framingham study, Mann et al. (61) found that iron intakes of women were low or below the Recommended Dietary Allowances for women at that time. They reported a negative association between hemoglobin levels and iron intake.

Monsen et al. (73) reported a study conducted on female students at the University of Washington in 1966. All of the subjects had normal

hematocrit levels. Their diets were studied for iron intake over a seven-day period. Iron content of the diet was determined and the diets were analyzed for iron content. There was a high correlation between calculated and analyzed iron values. Analyzed values for iron ranged from 0.77 to 24.6 mg per day while calculated values ranged from 2.4 to 24.0 mg per day. Average daily iron intake by analysis was 9.2 mg. This was less than 2/3 of the Recommended Daily Allowances for women at that time.

An attempt was made to evaluate the iron status of these women. None was anemic. However only 2 of 12 subjects had normal iron stores in the bone marrow. Five per cent had decreased transferrin saturation. The authors concluded that iron depletion is frequently caused by a low-iron diet and that there is a considerable incidence of iron deficiency in women in the United States.

In a study of teen-age pregnant and non-pregnant girls in California in 1972, King et al. (74) found that nutrients most poorly supplied before, during and after pregnancy were calcium, iron, and Vitamin A. Mean dietary intake of iron was 9 mg per day, with some diets having as little as 4 mg of iron per day. The diets of both pregnant and non-pregnant girls were below RDA for iron and a majority were below 1/2 for RDA for iron. Anemia was diagnosed in 27 per cent of the pregnant girls. The authors concluded that teen-age girls in general eat a poor diet whether pregnant or not.

White (75) found that girls from 15 to 17 have less iron per 1000 calories than women. The meat group is the major source of their iron intake. The diets of girls and women on the whole average 10 to 11 mg

of iron per day. This is only 55 to 60 per cent of the present RDA for iron which is 18 mg per day. Iron status should be evaluated by means other than dietary calculations because of the factors involved in absorption and utilization of dietary iron. It was stated further that the incidence of iron deficiency anemia among girls and women is 3.5 to 7.0 per cent as evidenced by hemoglobin and hematocrit levels. However, many non-anemic girls and women may be iron deficient. One-third of college women who were in "excellent health" had no iron stores in the bone marrow.

When using 12.5 g per 100 ml as the lower unit of acceptable hemoglobin levels and 36 per cent as the lower limit of acceptable hematocrit levels, anemia was found in 5 to 10 per cent of women in another study (53). However anemia was prevalent in only 3.6 per cent of girls. The prevalence rates for anemia in the United States seem to be 5 per cent among white females and 2 per cent among Negro females.

Verloop (39) reports that the percentage of "normal women" who have iron depletion varies from 20 to 30 per cent. The percentage of women who have iron-deficiency anemia (hemoglobin lower than 12.5 g/100 ml) varies from 2 per cent to 25 per cent. He stated further that iron depletion is the rule rather than the exception in pregnancy because 30 to 40 per cent of women enter pregnancy with depleted iron stores.

In all of the studies reviewed, the average daily iron intake of girls is below the Recommended Allowances of 10 mg per day. Anemia is present in only about 5 to 10 per cent, but inadequate iron stores are common.

Therapy for Iron Deficiency and Anemia

Methods of treatment of iron deficiency consist of supplying iron through diet, oral iron supplements or parenteral therapy. Iron therapy by dietary means is slow and due to absorption factors not always reliable. The Recommended Allowance for iron is most difficult to provide in the diet. Liver, other organ meats, dried fruits, legumes, shellfish, and molasses are iron rich foods (8). Other good food sources of iron are red meat, egg yolk, whole wheat, green leafy vegetables, and nuts (10).

Cooking procedures may be an important factor in determining the amount of iron actually present in the food (76). Cast-iron cookware was widely used several years ago but its use had declined in recent years and the use of stainless steel and aluminum taken its place. There is a considerable uptake of iron from the skillet by the food (1, 8). The longer a food is in contact with the skillet, the more iron it absorbs. Acid foods tend to absorb the iron better than non-acid foods. However, food iron compounds are generally less available for absorption than iron salts (28).

Therefore, the treatment of choice for oral use is an iron preparation. Ferrous salts are more easily absorbed than ferric salts because the ferrous salts are already in a reduced state (15). Ferrous sulfate may be regarded as the standard with which all other iron preparations are compared (2). It is the most widely used iron preparation and well-tolerated in 90 per cent of the patients who take it. It is also the least expensive. Other iron salts which can be used are fumarate, gluconate, succinate, lactate, glutumate and glycine sulfate (3). They offer no advantage over ferrous sulfate and may be more costly. Syrups

are more effectively absorbed than iron tablets. Tablet efficiency may vary due to the type of coating it has (15).

The iron salt is given after meals to avoid gastrointestinal upsets. Bothwell and Finch (15) state that adequate therapy would be 0.4 mg of a ferrous salt per mg of body weight three times a day. Georgio (25) recommends 180 mg of elemental iron daily which would be three USP 0.3 g ferrous sulfate tablets. He does not agree with giving a vitamin-mineral supplement because the preparation may mask other deficiencies.

When oral treatment is initiated, hemoglobin regeneration occurs at the rate of 0.2 to 0.3 g per day during the first few weeks (25, 77). No appreciable hemoglobin rise should be expected until the second week following start of therapy (25). Oral therapy should continue two to three months beyond the time of hemoblobin regeneration to allow for repletion of iron stores (2, 25).

A slightly faster hemoglobin response has been noted when parenteral iron is given (78). The parenteral iron compound used most frequently is iron dextran. Several injections are usually required and may leave the injection site discolored and sore.

Extended iron therapy has certain disadvantages (79). The patient may fail to take the oral dose regularly or, if taking parenteral iron, may fail to receive the full series of injections. Because of this, many authorities now recommend more liberal iron fortification of food (25, 78). There is at the present time, however, no agreement on the exact amount of fortification necessary.

Many studies have been reported which show the nutritional status of teen-age girls in relation to iron nutriture. Because this is a

vulnerable age group, it is important that studies be continued aimed toward improving nutritional and iron status of these girls.

CHAPTER III

EXPERIMENTAL METHOD

This study was conducted for the purpose of determining the iron status of high school home economics students using a dietary intake record and laboratory data. Permission for using humans in this research was given by the Committee on Research and/or Experimentation Involving Human Subjects at Oklahoma State University. Permission to work with the students was given by the Superintendent of Warner Schools and the Vocational Home Economics Teacher at Warner High School. Students who were currently enrolled in Home Economics in grades 9 through 12 from Warner, Oklahoma were the subjects for this study done during August, 1973. This was done during the second week of school. Ages ranged from 14 to 19 with most of the subjects' ages falling between ages 14 and 17.

At an initial meeting the researcher met with each class to explain the purpose of the study and ask for volunteers. Sixty-five girls volunteered. They were given letters of explanation and permission sheets to take home to their parents. At the second meeting 61 girls had obtained parental permission to participate. Of this number, 54 girls completed all phases of the study. Only these 54 girls were used as respondents. This group of girls was then given an information sheet and three day dietary records to complete. See Appendix A. The dietary sheets were filled out for three consecutive days during the middle of

the week because it was felt this would be a more representative picture of the eating pattern of each girl. At the third meeting the dietary records and information sheets were collected.

Blood samples were collected by a laboratory technician. A heparinized micropipette (44.7 microliter) was filled with blood and emptied into a Unopette reservoir.[1] The reservoirs were labeled at that time. After blood samples were drawn from each subject they were analyzed in a Coulter Counter, Model "S"[2] in the laboratory at Muskogee General Hospital by a Medical Technologist. In this procedure the blood mixture in the Unopette reservoir is aspirated into the Counter. The white blood count, red blood count and mean cell volume are counted and sized electronically. The hemoglobin is determined by converting the hemoglobin to cyanmethemoglobin which is measured by a photo-sensitive device. The MCH, MCHC, and hematocrit are calculated values derived from the red blood cell count, MCV and hemoglobin. The results of each blood test were then printed electronically on a special card which has a set of normal values printed on it for comparison.

The dietary records were analyzed for calories, protein and iron content of the diet using a computer program based on USDA Home and Garden Bulletin No. 72 (80) and also using Food Values of Portions Commonly Used (81). A mean intake for the three days for each of the three

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[1]The Unopette Disposable Pipetting System No. 5840, consisting of a disposable pipette and a plastic reservoir, is manufactured by Becton-Dickinson especially for the Coulter Counter. The reservoirs contain a 10.0 ml solution of isoton which dilutes the blood 1:224.7. The Unopettes can be obtained from Becton-Dickinson, Rutherford, New Jersey 07070.

[2]The Coulter Counter Model "S" is manufactured by Coulter Electronics, 590 West 20th Street, Hiaeleah, Florida 33010.

days for each of the three nutrients was determined. These were compared to the Recommended Dietary Allowances for girls in this age group. The three day dietaries for each girl were further analyzed for adequacy in meeting the recommendations of the Daily Food Guide (Basic Four).

A short nutrition quiz was taken by each girl at the third meeting to help ascertain her knowledge of nutrition. The quiz was graded and results rated good to poor according to number of questions answered correctly.

After all the data was analyzed the researcher visited each class to explain the results.

CHAPTER IV

RESULTS AND DISCUSSION

This study was conducted to determine the iron status of a group of high school home economics students in ninth through twelfth grades. Fifty-four girls ages 14 to 19 were the subjects for this study. Each girl completed a three day dietary record, an information sheet, and a nutrition quiz. Finger-prick blood samples were taken and hemoglobin, hematocrit, and red cell indices were determined for each subject.

Nutrient Intake

The dietary records were analyzed for calorie, protein, and iron intake for each girl. Range of dietary intakes of calories, protein, and iron are shown in Table II. There was a wide range of nutrient intake among the subjects. Mean levels of intakes are shown in Table III. Average daily calorie, protein, iron intakes for each girl were compared to the Recommended Dietary Allowances (Appendix B) for girls ages 14 to 18. The individual nutrient intakes for each subject are shown in Appendix B.

At the ninth grade level, none of the girls met the RDA for calories or iron and 11 of 18 did not meet the RDA for protein. Calorie intakes ranged from 990 to 2110 with the mean intake 1640 calories per day. Protein intakes ranged from 31 to 71 g per day with the mean intake 48 g per day. Iron intakes ranged from 3.7 to 15 mg per day with

the mean intake 7.4 mg per day. One girl had an iron intake of 15.0 mg per day using "Instant Breakfast"--an iron-fortified product. Use of vitamin-mineral supplements was negligible. Of the three girls who reported using a supplement none took one regularly.

TABLE II

RANGE OF NUTRIENT INTAKES ACCORDING TO GRADE OF PARTICIPANTS

Grade	No. of Students	Calories	Protein (g)	Iron (mg)
Recommended Level		2300 - 2400	55	18
9th	18	990 - 2110	31 - 71	3.7 - 15
10th	15	530 - 1560	21 - 68	2.0 - 10.5
11th	12	350 - 2210	6 - 84	0.2 - 10.3
12th	9	460 - 2400	20 - 85	2.2 - 14.3

TABLE III

MEAN LEVELS OF NUTRIENT INTAKES ACCORDING TO GRADE

Grade	Calories	Protein (g)	Iron (mg)
9th	1640	48	7.4
10th	1160	42	5.6
11th	1180	41	5.1
12th	1525	53	7.3

At the tenth grade level none of the girls met the RDA for calories or iron and 13 of 15 did not meet the RDA for protein. Calorie intakes ranged from 530 to 1560 per day with mean intake of 1160 calories per day. Protein intake ranged from 21 to 68 g per day with the mean intake 43 g per day. Iron intakes ranged from 2.0 to 10.5 mg per day with the mean intake 5.6 mg per day. Two girls reported infrequent use of vitamin-mineral supplements.

At the eleventh grade level none of the girls met the RDA for calories or iron and 6 of 12 did not meet the RDA for protein. Calorie intakes ranged from 350 to 2210 with the mean intake of 1180 calories per day. Protein intakes ranged from 6 to 84 g per day with the mean intake 41 g per day. Iron intakes ranged from 0.2 to 10.3 mg per day with the mean intake 5.1 mg per day. One girl reported using a vitamin-mineral supplement irregularly.

At the twelfth grade level, one girl met the RDA for calories, none met the RDA for iron, and four of nine did not meet the RDA for protein. Calorie intakes ranged from 450 to 2400 per day with a mean intake 1525 calories per day. Protein intakes ranged from 20 to 85 g per day with a mean intake of 53 g per day. Iron intakes ranged from 2.2 to 14.3 mg per day with a mean intake of 7.3 mg per day. One girl reported taking an iron supplement daily and one girl reported eating liver on one of the days.

It can be seen from Figure 3 that none of the mean nutrient intakes met 100 per cent of the Recommended Allowances. Mean intakes of calories by percentage of RDA were: 68 per cent for ninth grade, 48 per cent for tenth grade, 51 per cent for eleventh grade, and 66 per cent for twelfth grade. The percentages of mean protein intakes by

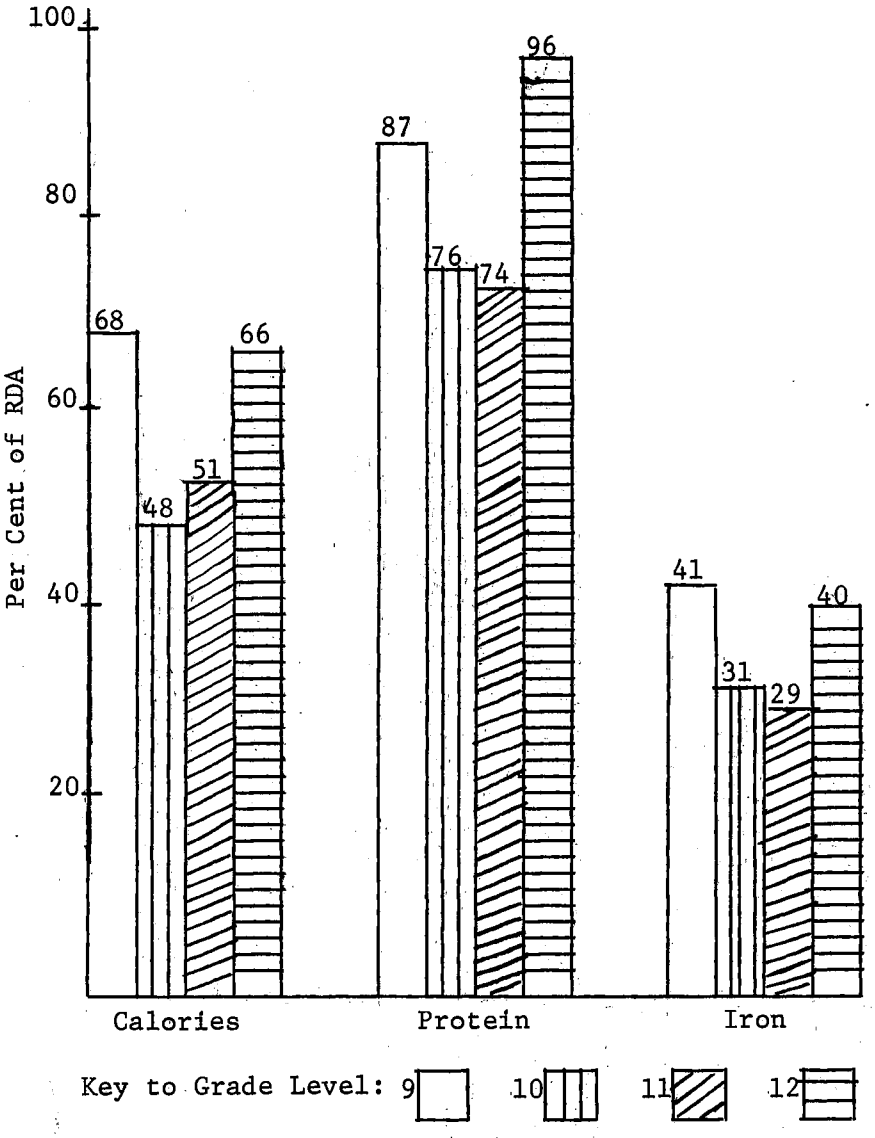

Figure 3. Per Cent of Recommended Dietary Allowances Met by Mean Intake of Each Nutrient According to Grade Level of the Subjects

percentages of RDA were: 87 per cent for ninth grade, 76 per cent for tenth grade, 74 per cent for eleventh grade, and 96 per cent for twelfth grade. Mean iron intakes by percentages of RDA met for iron were: 41 per cent for ninth grade, 31 per cent for tenth grade, 29 per cent for eleventh grade, and 40 per cent for twelfth grade.

The intakes of each nutrient decreased from ninth to tenth grade. Protein and iron intakes decreased from tenth to eleventh grade, while calorie intake rose slightly. Nutrient intakes increased during twelfth grade, but did not reach the levels of the ninth grade students.

The diets of all the girls showed an average iron intake of 4.6 mg per 1000 calories. This is below the 6 mg per 1000 calories which is the usual intake in the normal American diet.

Most of the nutritional studies done on teenage girls have found low dietary intakes of iron. The U.S.D.A. Food Consumption Survey of 1965 (56) showed that dietary intakes of iron were around 10.5 mg per day. The Ten-State Survey (72) found that iron intakes of teenage girls were generally less than 13.5 mg per day. The study by King et al. (74) on teenage girls showed average iron intakes of 8 mg per day. The present study showed much lower mean intakes of iron. The mean intake of iron was less than 44 per cent of the RDA for iron. Although the Ten-State Survey found dietary intakes of protein above levels considered adequate, King et al. (74) found average protein intakes of 52 g per day. The mean intakes in the present study were generally lower possibly due to a high incidence of snacking. A wide range of calorie intakes for teenage girls have been found in all of the studies. King et al. (74) found that teenage girls consume around 1400 calories per day which is considerably less than the Recommended Allowance. The

present study also found that the mean calorie intakes were less than the RDA for calories for teenage girls.

Daily Food Guide and Meal Patterns

The diets of each girl were analyzed for adequacy in meeting the recommendations of the Daily Food Guide (Basic Four). The diets were rated good if a subject ate foods from all four food groups and met the required amount of three groups; fair if a subject ate foods from all four food groups and met the required amount of two groups; and poor if (a) all four food groups were not represented in the diet, or (b) if the four food groups were represented, but required amounts not met.

At the ninth grade level, two girls had good diets, 12 had fair diets, and four had poor diets. At the tenth grade level, none of the girls had good diets, four had fair diets, and 11 had poor diets. At the eleventh grade level, none of the girls had good diets, five had fair diets, and seven had poor diets. At the twelfth grade level, one girl had a good diet, six had fair diets, and two had poor diets. These results are shown in Table IV.

When compared to the Basic Four, the diets of the subjects were shown to decrease in adequacy during tenth and eleventh grades. Eighteen of the 27 tenth and eleventh grade students had diets rated poor (66 per cent) as compared to 21 per cent rated poor for ninth graders and 22 per cent rated poor for twelfth graders. The two food groups most frequently absent or found in only small amounts in the diet were the Milk Group and the Fruit and Vegetable Group.

When recording meal patterns, it was found that of the 54 girls, 20 skipped breakfast entirely. Fifteen others had an inadequate breakfast

consisting only of such items as soda pop, ice cream, or coffee. Twelve girls skipped lunch entirely. Of the 32 girls who reported eating lunch at a restaurant, cafe, or hamburger stand, 20 of these reported consuming only soda pop or soda pop and such snack foods as chips or candy. Ten of the girls reported eating lunch at the school. Their diets were better balanced according to the Basic Four and had higher nutrient intakes than those who ate lunch elsewhere. All of the girls reported eating dinner.

TABLE IV

ADEQUACY OF DIETS OF THE SUBJECTS AS COMPARED TO THE BASIC FOUR FOOD GROUPS

Grade	Good	Fair	Poor
9th	2	12	4
10th	0	4	11
11th	0	5	7
12th	1	6	2
Total	3	27	24

Snacking was very common. Over two-thirds of the girls reported snacking at least once a day every day and the other one-third reported snacking four or more times a week. Snack foods accounted for 30 per cent of the calories per day in 75 per cent of the girls. Most frequent snack foods consumed were soda pop, chips and candy. Ten girls reported consuming four or more cokes per day. Empty calorie snack foods were

the choice of most of the girls. Only a very few choose snack foods such as fruit, milk and cookies, or ice cream.

Results of Blood Analysis

Blood levels for each subject were compared to the normal values published for use with the Coulter Counter (Appendix B). Hemoglobin, hematocrit, and red cell indices were evaluated. Distribution of hemoglobin and hematorcrit values are shown in Table V.

For ninth grade students, hemoglobin levels ranged from 11.7 g per 100 ml to 15.3 g per 100 ml with a mean level of 12.9. Hematocrit levels ranged from 24.6 per cent to 45.5 per cent with a mean hematocrit of 39.0 per cent. Red cell indices were in the normal range for all subjects. Normal values for hemoglobin, hematocrit, and red cell indices are shown in Table XII, Appendix B.

For tenth grade students hemoglobin levels ranged from 11.5 to 14.3 with the mean level 12.8. Hematocrit levels ranged from 33.8 to 41.4 with a mean level of 37.3. Red cell indices were in the normal range.

For eleventh grade, hemoglobin levels ranged from 12.1 to 13.8 with the mean hemoglobin level 12.8. Hematocrit levels ranged from 35.9 to 40.0 with the mean hematocrit level 38.2. Red cell indices were in the normal range.

For twelfth grade students, hemoglobin levels ranged from 12.2 to 13.8 with a mean level of 12.9. Hematocrit levels ranged from 36.7 to 40.9 with a mean level of 28.6. Red cell indices were in the normal range.

The mean hemoglobin levels decreased in tenth and eleventh grades and then increased again in twelfth grade. Hematocrit levels dropped in

TABLE V

DISTRIBUTION OF HEMOGLOBIN AND HEMATOCRIT VALUES
BY GRADE LEVEL

Grade	Hemoglobin Values			
	Below 12.0	12.0 to 12.4	12.5 to 13.0	Above 13.0
9	1	1	7	9
10	3	3	4	5
11	0	3	5	4
12	0	2	3	4

Grade	Hematocrit Values			
	Below 34.0	34.0 to 37.0	37.0 to 40.0	Above 37.0
9	0	1	14	3
10	1	4	8	2
11	0	3	9	0
12	0	2	4	3

the tenth grade and rose in the eleventh and twelfth grades but did not reach the level of ninth grade students (Figures 4 and 5).

When a hemoglobin level of 12.0 g per 100 ml is used as the lower limit of normal, as suggested by Wintrobe, four girls or 7 per cent of the entire group were below the lower limit. A hemoglobin level of 12.5 g per 100 ml is used by other investigators as the lower limit of normal and 13 girls or 24 per cent were found to be below this lower limit. Hematocrit levels below 37, which is the normal level, were found in 11 girls.

Individually most of the girls who had low hemoglobin and hematocrit levels also had low dietary intakes of iron and ate a poor diet according to the Basic Four. However, one girl who did eat a well-balanced diet did have low hemoglobin levels.

Low dietary intakes of iron did not correlate consistently with low hemoglobin and hematocrit levels. A higher correlation might be shown by a long-term study of dietary intakes of iron and hemoglobin and hematocrit levels.

Nutrition Quiz Results

The nutrition quiz was given to help ascertain the girls' knowledge of nutrition. The quiz contained 25 questions and was graded excellent if 22 to 25 questions were correct; good if 18 to 21 were correct; fair if 14 to 17 were correct; and poor if 13 or less were correct. The results are shown in Table VI.

The results showed that most of the girls had the knowledge of nutrition they needed to choose a well-balanced diet. They generally

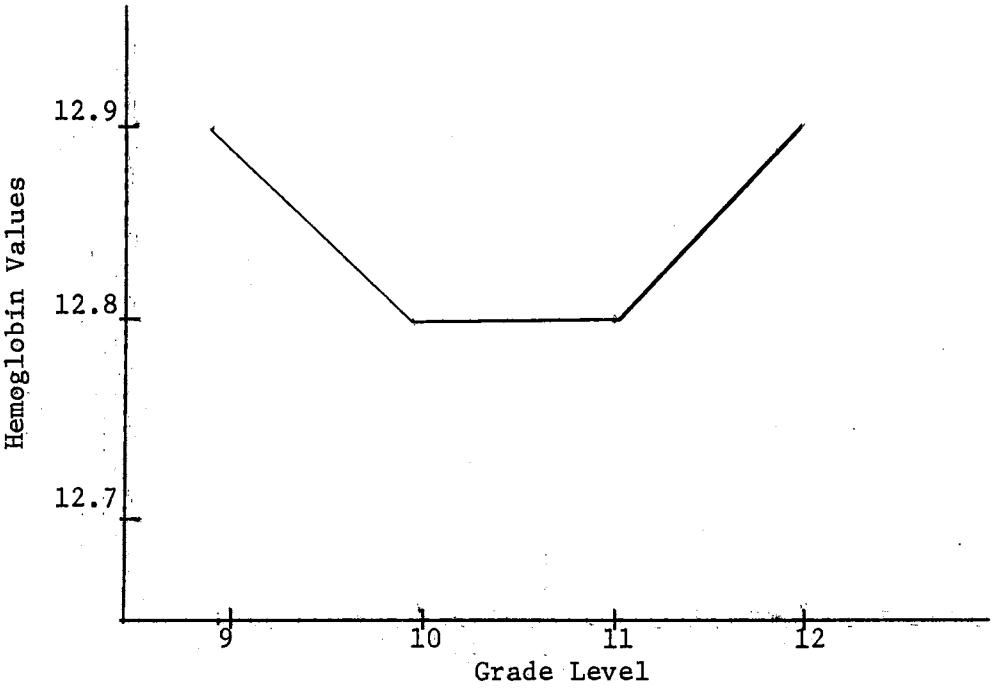

Figure 4. Mean Hemoglobin Values According to Grade Level of Subjects

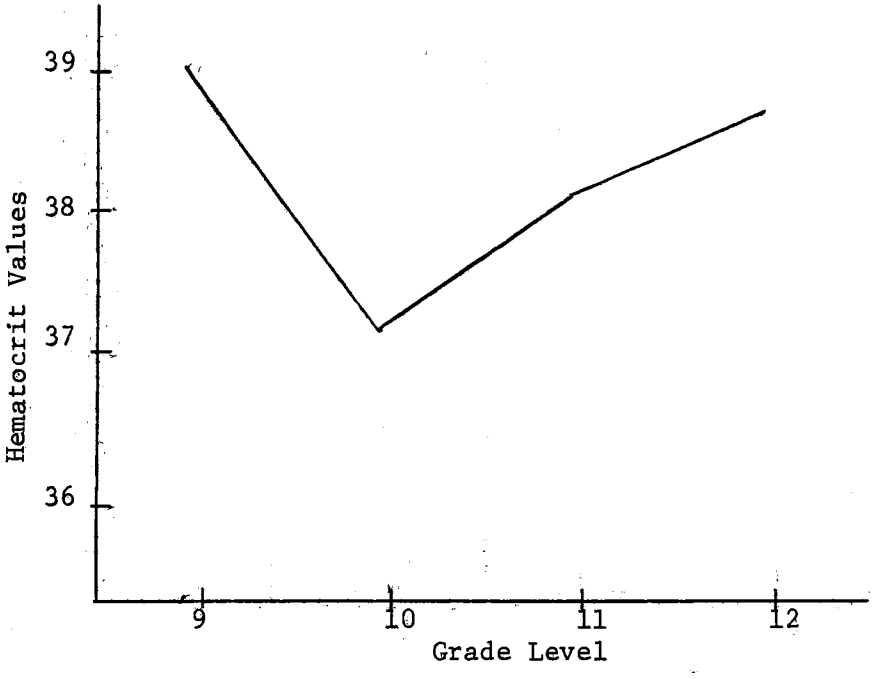

Figure 5. Mean Hematocrit Values According to Grade Level of Subjects

did not use this knowledge as indicated by the foods they chose to eat.

TABLE VI

DISTRIBUTION OF NUTRITION QUIZ RESULTS
BY GRADE LEVEL OF SUBJECTS

Grade	No. of Students	Excellent	Good	Fair	Poor
9th	18	2	9	7	0
10th	15	0	4	8	3
11th	12	0	8	4	0
12th	9	0	6	0	3
Totals	54	2	27	19	6

Education Levels

Of the 54 girls in this survey, only 14 had parents who had any college education. Four girls had parents who were both college graduates. Twenty girls had parents who both finished high school but who had no college education. Twenty others had parents one or both of whom had not finished high school. There did not seem to be any relation between the educational levels of the parents and the dietary habits of the girls.

Other Dietary Factors

It was interesting to note that 30 girls reported using iodized

salt regularly at home, five reported using it sometimes, and 19 reported never using it. There were also 16 girls who did not use fortified milk of any kind. Forty girls reported using iron skillets infrequently at home, which would be expected to be a possible iron source. Vitamin-mineral supplements were used by only seven girls and only two used them regularly.

Application of Findings

When the study was completed, the results were reported and discussed with all the subjects. The subjects were interested in the results and posed many questions about ways of improving their diets. Based on the findings of the study and responses by the subjects, opportunities for further nutrition education with regard to nutrient intake are many.

CHAPTER V

SUMMARY AND CONCLUSIONS

Fifty-four volunteer high school home economics students at Warner High School between the ages of 14 and 19 were the subjects for this study. After parental permission had been obtained, each girl completed a dietary history, a three day dietary record, and a nutrition quiz. This was done to see if they had the knowledge to choose a well-balanced diet and if they used this knowledge when choosing the diet. Finger-prick blood samples were taken to determine hemoglobin, hematocrit, and red cell indices. These determinations were done using the Coulter Counter, Model "S" to give an indication of iron deficiency in these girls. The dietary information was analyzed for calorie, protein, and iron intake using a computer program to see if Recommended Dietary Allowances for these nutrients were met. The diets themselves were compared to the Daily Food Guide (Basic Four) to see if the girls chose a well-balanced diet.

For each nutrient studied, mean intakes were found to be below Recommended Daily Allowances. It was hypothesized that the majority of girls would have diets which were below the RDA for protein and iron. This was found to be true. No girl in the study met the RDA for iron. Thirty-seven of the 54 girls did not meet the RDA for protein. It was also found that only one girl out of the 54 studied met the RDA for

calories. The overall iron intake from the diet was 4.6 mg per 1000 calories which is lower than the national average.

Mean intakes of calories, protein, and iron decreased from ninth to tenth grade and from tenth to eleventh grade. Twelfth grade students had better intakes than tenth and eleventh grade students, but were still below ninth graders with regard to calorie and iron intakes. The per cent of the Recommended Allowances met by the diets also decreased by grades in regard to all nutrients studied, except that twelfth grade students had an increase in protein intake.

When compared to the Daily Food Guide, the diets of the subjects also showed a decrease in adequacy during tenth and eleventh grades. Eighteen of the 27 tenth and eleventh grade students had diets rated poor (66 per cent), while only four ninth graders (21 per cent) and two twelfth graders (22 per cent) had diets rated poor. The results showed that eating patterns were good in ninth graders, became poor during tenth and eleventh grades, then improved during the twelfth grade.

It was hypothesized that the majority of teen-age girls would not eat a well-balanced diet, even though they had the knowledge of how to choose such a diet. This was found to be true. The majority of the quiz results were good, but the majority of the diets were fair and poor.

Hemoglobin levels below 12 g per 100 ml were found in four girls. Hemoglobin levels below 12.5 were found in nine girls. These lower levels were more common in grades 10 and 11. This would put the incidence of low iron levels in the blood at 7 per cent or 24 per cent depending on which level is used as the lower limit of normal. Hematocrit levels below 37 were found in 11 girls. The majority of the

girls had hemoglobin levels above 12.5 g per 100 ml and hematocrit levels above 37.0. Mean hemoglobin and hematocrit levels decreased among tenth and eleventh grade students and rose during the twelfth grade but did not rise to the level of the ninth graders.

Of the girls completing the study, all with low hemoglobin levels had poor diets except one. There did not seem to be a relationship between dietary intakes of iron and low hemoglobin levels.

The findings of this study bear out the findings of other studies indicating that it is difficult to influence teen-age girls with regard to their eating patterns. If the girls in this age group could be encouraged to meet the recommendations of the Daily Food Guide, their diets would improve considerably.

Recommendation for Further Study

This study was conducted at the beginning of the school year. After the follow-up visit to the school, the author felt that the eating patterns of the girls may have been better during the summer months and that the poor eating habits exhibited during the three days had not yet influenced hemoglobin levels of the girls. It is felt that a follow-up study done during the middle of the school year would show more clearly the influence of low dietary iron intakes on hemoglobin levels. It might also show more clearly the eating habits of the subjects. It is suggested that some determination of iron stores also be done to assess the incidence of iron depletion at this age level.

It is also felt that a long-term study should be done on teen-age girls and their eating habits. If a study were conducted over a longer

period of time, correlation between blood levels of hemoglobin and dietary intakes of iron might be higher.

Further studies on the snacking patterns of these girls would be helpful in convincing school personnel of the importance in providing nutritious snack foods at the school. The poor selection of snacks made by many of the subjects was considered to contribute to the generally poor dietary intakes of nutrients.

Student participation in projects involving eating habits and determination of nutrient intake in relation to the total health of the student appear to be very effective.

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APPENDIX A

INFORMATION SHEET

1. Name_____ Grade_____

2. Height_____ 3. Weight_____ 4. Age_____

5. Have you had any recent illnesses?_____ If so, what?_____

_____

6. Does your family use iron cooking utensils?_____ If so, what kind?

_____

7. Do you take a vitamin-mineral supplement of any kind?_____
I
If so what?_____

Does it contain iron or any ferrous or ferric compound?_____

If so state type and amount._____

8. Circle the highest level of education attained by your parents.

Father		Mother	
1		1	
2	College:	2	College:
3	1	3	1
4	2	4	2
5	3	5	3
6	4	6	4
7	Other:	7	Other:
8		8	
9	_____	9	_____
10		10	
11	_____	11	_____
12		12	

9. Check the sources of your food supplies and meals.

_____Garden
_____Grocery Store
_____Freezer, beef, chicken, pork
_____Other

_____Commodities
_____School lunch
_____Restaurant

10. Is the milk you use at home fortified with Vitamin A or Vitamin D?
Vitamin A_____

Vitamin D_____

11. Is the salt you use at home iodized?_____

12. Do you have any allergies to food?_____ What_____

13. Do you have any strong food dislikes?_____ What_____

14. Have you ever been on a special diet?_____ What is it?_____

Are you on it now?_____

Dietary Intake Record Sheet

FOODS	Breakfast		Lunch		Supper		Snacks	
	Kind and amount	How cooked	Kind and amount	How cooked	Kind and amount	How cooked	Kind and amount	How cooked
Fruit or Juice								
Cereal								
Bread (biscuit, toast, etc.)								
Egg								
Milk								
Coffee								
Jelly, syrup, sugar								
Roll, doughnut								
Butter or margarine								
Meat, fish, cheese								
Vegetable								
Starch (potatoes, rice, macaroni, etc.)								
Salad								
Salad dressing								
Soda pop or other beverage								
Dessert								
Potato chips								
Candy bar								
Snack cakes								
Gum								

APPENDIX B

TABLE VII

RECOMMENDED DIETARY ALLOWANCES, 1968

Nutrient	Girls, Ages 14 - 16	Girls, Ages 16 - 18
Calories	2400 Kcal	2300 Kcal
Protein	55 g	55 g
Iron	18 mg	18 mg

TABLE VIII

INDIVIDUAL NUTRIENT INTAKES, 9TH GRADE

Student No.	Basic 4	Test	Cal	Pro	Fe	HgB	Hct	MCV	MCH	MCHC
1	Fair	Good	1520	43	7.7	13.3	38.9	88	29.9	34.4
2	Fair	Good	1410	58	7.9	13.1	39.2	87	28.6	33.4
3	Good	Good	1880	71	11.0	12.5	37.3	91	30.5	33.7
4	Fair	Good	1995	65	15.0	12.9	39.1	92	30.4	33.2
5	Poor	Good	1781	46	7.0	13.1	39.1	91	30.5	33.7
6	Poor	Fair	1932	36	5.0	15.3	45.5	89	29.5	33.6
7	Fair	Good	1900	50	7.0	12.5	37.8	87	28.5	33.2
8	Fair	Fair	994	36	6.0	13.2	39.8	91	29.9	33.2
9	Fair	Fair	1768	38	6.5	13.9	40.4	90	30.7	34.5
10	Good	Good	2110	62	11.7	11.7	34.6	82	27.6	33.9
11	Fair	Fair	1490	35	6.0	13.3	39.2	92	31.1	33.9
12	Fair	Fair	1690	38	7.0	14.2	42.7	94	31.2	33.3
13	Fair	Fair	1030	31	3.7	12.6	37.4	85	28.7	33.9
14	Fair	Good	1540	64	8.6	13.5	39.2	89	30.5	34.5
15	Fair	Fair	2040	63	8.5	12.7	39.1	89	28.9	32.7
16	Poor	Good	1210	46	4.4	13.0	39.1	91	29.8	33.2
17	Poor	Exc.	1540	55	6.0	12.4	37.1	94	31.2	33.6
18	Fair	Exc.	1780	35	5.0	12.7	37.8	88	29.2	33.6

TABLE IX

INDIVIDUAL NUTRIENT INTAKES, 10TH GRADE

Student No.	Basic 4	Test	Cal	Pro	Fe	HgB	Hct	MCV	MCH	MCHC
1	Poor	Good	1320	42	5.0	12.6	37.1	89	30.1	34.2
2	Poor	Good	1130	39	5.4	12.9	37.3	88	30.2	34.6
3	Poor	Fair	1050	28	3.7	11.6	34.8	92	30.5	33.6
4	Poor	Poor	735	21	2.0	12.8	37.6	88	30.0	34.3
5	Poor	Fair	890	43	6.1	12.8	37.3	89	30.5	34.5
6	Fair	Fair	1015	41	6.2	11.7	34.8	83	27.8	33.7
7	Poor	Poor	1300	68	7.9	14.2	40.9	88	30.5	34.9
8	Fair	Fair	1560	69	10.5	14.3	41.4	89	30.5	34.6
9	Poor	Fair	1080	42	5.4	13.1	38.7	86	28.7	33.8
10	Poor	Poor	995	41	4.5	12.4	37.4	93	30.6	33.1
11	Fair	Fair	1390	43	6.5	12.0	35.4	89	30.0	34.0
12	Poor	Good	1280	34	4.4	12.3	35.5	87	29.9	34.7
13	Fair	Fair	1500	52	7.4	13.3	39.5	92	30.8	33.6
14	Poor	Good	1080	30	4.1	11.5	33.8	86	29.4	34.2
15	Poor	Fair	1130	47	6.1	13.1	38.5	88	29.8	34.2

TABLE X

INDIVIDUAL NUTRIENT INTAKES, 11TH GRADE

Student No.	Basic 4	Test	Cal	Pro	Fe	HgB	Hct	MCV	MCH	MCHC
1	Fair	Good	1650	75	10.2	13.2	39.2	92	30.8	33.8
2	Fair	Good	2210	84	10.3	13.8	39.8	89	30.4	34.8
3	Poor	Fair	1340	41	6.1	12.1	35.9	82	27.5	33.9
4	Poor	Good	660	19	3.6	13.0	38.2	95	32.1	34.1
5	Poor	Good	950	26	3.8	13.3	39.4	85	28.4	33.9
6	Poor	Fair	350	6	.2	12.6	38.6	93	30.0	32.7
7	Poor	Fair	1200	31	3.6	13.0	39.3	93	30.5	33.2
8	Fair	Good	1640	42	6.7	12.2	36.3	85	28.3	33.6
9	Poor	Good	550	32	3.3	12.5	37.6	89	29.4	33.3
10	Fair	Good	1300	57	4.5	12.3	36.7	88	29.3	33.7
11	Poor	Fair	1150	39	5.0	13.7	40.0	81	27.4	34.4
12	Fair	Good	1150	42	5.1	12.9	37.6	86	29.4	34.3

TABLE XI

INDIVIDUAL NUTRIENT INTAKES, 12TH GRADE

Subject No.	Basic 4	Test	Cal	Pro	Fe	HgB	Hct	MCV	MCH	MCHC
1	Fair	Good	2100	85	11.0	13.1	39.7	98	32.1	32.9
2	Fair	Good	950	20	2.2	12.7	37.6	86	28.9	33.9
3	Good	Good	1875	74	14.3	12.9	40.2	94	30.0	32.1
4	Poor	Poor	1080	27	3.4	12.2	36.9	91	29.8	33.0
5	Fair	Poor	1460	60	5.2	13.8	30.9	88	29.6	33.8
6	Poor	Poor	460	38	3.6	13.2	40.1	86	28.2	33.0
7	Fair	Good	2400	65	10.9	12.4	36.7	89	29.8	33.9
8	Fair	Good	1840	62	8.2	12.5	37.1	91	30.5	33.8
9	Fair	Good	1560	49	7.0	13.4	39.0	90	30.8	34.5

TABLE XII

NORMAL BLOOD VALUES FOR A FEMALE
USED WITH COULTER COUNTER

Value	Normal
Hemoglobin (g)	12 - 16
Hematocrit (%)	37 - 47
MCV (ug)	82 - 92
MCH (uug)	27 - 31
MCHC (%)	32 - 36

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